Dakota Pearl: An Attractive, Bright White-skinned, Cold-Chipping Cultivar With Tablestock Potential

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ABSTRACT

Dakota Pearl (ND2676-10) is a medium-maturing chipping cultivar with uniform, round, bright white-skinned tubers with shallow eyes. Dakota Pearl has the ability to produce commercially acceptable chips following long-term storage at 5.5 C without the need for reconditioning. It yields well under both dryland and irrigated trial conditions in North Dakota. North Central Regional Potato Variety Trial and Snack Food Association Trial results indicate it has wide adaptability. Yield and specific gravity under dryland conditions are similar to Norchip; Dakota Pearl has a low percentage of external defects. Average set is 12 to 14 tubers per hill. Dakota Pearl demonstrates wide consumer appeal as a tablestock cultivar due to attractive tuber appearance and bright-white skin. Sensory evaluation scores for baking, boiling, and microwaving are comparable to those of standard chip cvs Atlantic, NorValley, and Snowden. The specific gravity of Dakota Pearl is similar to cvs Norchip and NorValley, lower than for Atlantic or Snowden. Total glycoalkaloid levels are low, at 1.5 mg/100 g fresh tuber tissue. The North Dakota Agricultural Experiment Station released Dakota Pearl on 23 April 1999.

RESUMEN

Dakota Pearl (ND2676-10) es un cultivar de papa para "chips," es de maduración media, con tubérculos de piel blanca brillante, redondos, uniformes y ojos poco profundos. Dakota Pearl produce "chips" comercialmente aceptables luego de ser almacenado por largo tiempo a 5.5 C y sin requerir reacondicionamiento. En ensayos realizados en North Dakota bajo condiciones de lluvia e irrigación, este cultivar mostró buen rendimiento. Los resultados de los ensayos del "North Central Regional Potato Variety" y Snack Food Association, indican que tiene una amplia adaptabilidad. El rendimiento y el peso específico, en suelos bajo lluvia son similares a Norchip; tiene un bajo porcentaje de defectos externos y el número de tubérculos promedio por planta es de 12 a 14. Dakota Pearl es un cultivar también para consumo fresco por la apariencia atractiva del tubérculo y su piel blanca brillante. El valor sensorial para horneado, hervido, o cocción en microondas es comparable al de los cultivares como Atlantic, NorValley y Snowden. El peso específico de Dakota Pearl es similar al de Norchip y NorValley, pero más bajo que el de Atlantic o Snowden. Los niveles de glicoalcaloides totales son bajos, 1.5mg/100g de peso fresco del tubérculo. La Estación Experimental Agrícola de North Dakota liberó el cultivar Dakota Pearl el 23 de Abril de 1999.

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ADDITIONAL KEY WORDS: *Solanum tuberosum*, cultivar, release, cold-chipping ability, *Solanum phureja*, *Solanum demissum*

INTRODUCTION

Dakota Pearl was evaluated as ND2676-10 and was released by the Agricultural Experiment Station of North Dakota and North Dakota State University (NDSU) on 23 April 1999. Since its release, Dakota Pearl has gained commercial acceptance in North Dakota and Minnesota, accounting for 4.9% and 1.0% of the planted hectareage in those states in 2003, respectively (NASS 2003). Dakota Pearl was derived from a cross between North Dakota selections ND1118-1 and ND944-6 that was made in 1984 at NDSU (Figure 1). The clone was initially selected at the Langdon Experiment Station at Langdon, ND, in 1985. Early evaluations were conducted at two locations in North Dakota. The initial cross, selection, and early testing of Dakota Pearl were done under the direction of Dr. Robert Johansen, NDSU (deceased). Advanced testing, seed increase, and commercial evaluation were done by several departments at NDSU, at the USDA-ARS Potato Research Worksite at East Grand Forks, MN, and by several certified seed and commercial producers in North Dakota and Minnesota. Public and private cooperators throughout the United States also provided assistance. Breeder's seed was produced at the Horticultural Research Farm, Absaraka, ND, and Agronomy Seed Farm, Casselton, ND. The North Dakota State Seed Department and cooperative certified seed producers under the guidance of the NDSU potato-breeding program and the NDSU Development Foundation made subsequent increases. Dakota Pearl was widely evaluated in replicated trials in nine locations from 1993 through 1998, and in regional trials at 23 North American sites (north-central USA and Canadian provinces) from 1996 to 1998.

The cultivar Norchip (Johansen et al. 1969) is in the ancestry of Dakota Pearl on both the female and male sides of the pedigree. Norchip was a chipping industry standard in the northern Great Plains for more than 25 years. Dakota Pearl is one-sixteenth *Solanum phureja*, represented on the maternal side of the pedigree in the background of ND1118-1. ND1118-1 was exceptionally resistant to cold-sweetening; however, tuber size was small and total yields low. The maternal parent of ND1118-1 was a high-protein breeding line from Minnesota. The paternal parent of MN2550 is largely derived from *S. phureja*. ND944-6 has the cultivar Lenape (Akely et al. 1968) and *S. demissum*, Nied. (approximately 1.5%) in its background. The observed cold-sweetening resistance of Dakota Pearl is likely derived from *S. phureja*, a species used by breeders as a source of this important trait (Lauer and Shaw 1970; Ehlenfeldt et al. 1990).

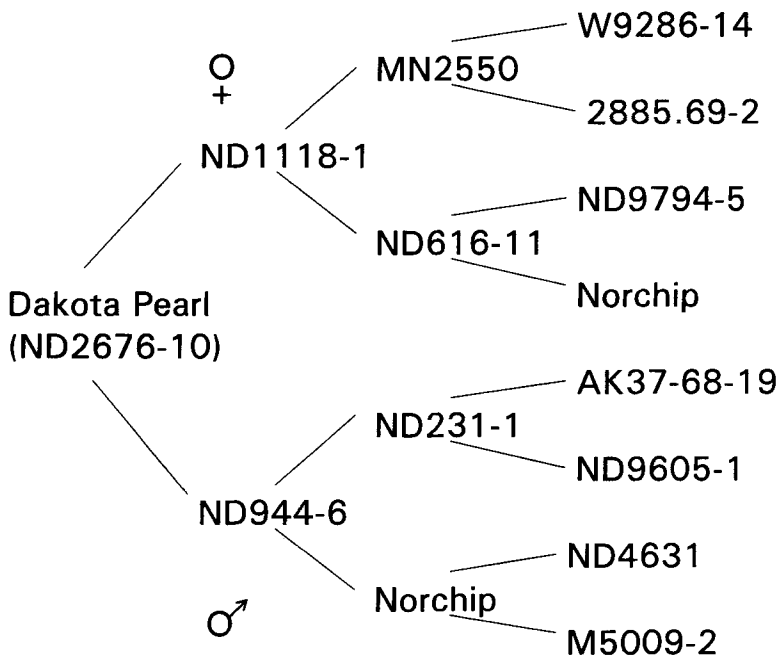

FIGURE 1.
Pedigree of Dakota Pearl.

DESCRIPTION

Plants

Growth habit: Vigorous, semi-erect vine; medium maturity. *Stems:* Weak anthocyanin pigmentation; weak stem wings. *Leaves:* Yellowish-green to olive green (147B, Royal Horticultural Society Color Chart [RHSCC]); pubescence sparse and short; leaf silhouette is medium; petiole anthocyanin pigmentation is absent. *Terminal leaflets:* Narrowly to moderately ovate shape with acuminate tip and obtuse to cordate base, medium leaflet margin waviness. *Primary leaflets:* Medium size, average of 4.9 pairs per leaf with narrowly

ovate shape, acute tip, and cordate base shape. *Secondary and tertiary leaflets:* Average of 4.0 pairs. *Stipules:* Large.

Flowers

Peduncle consists of nine to 15 buds and branches into two sections. The pedicel articulation is located one-half the length of the pedicel and is green in color. *Buds:* Moderately pubescent. *Calyx:* Pubescent and acuminate. *Corolla:* White (157A, RHSCC), pentagonal in shape, with a mean diameter of 24 mm. *Anthers:* Five; broad, cone shaped; yellow-orange (15A, RHSCC). *Pollen:* Abundant. Successful hybridizations occur with Dakota Pearl used either as the female or male parent. *Stigma:* Capitate; medium green (147A, RHSCC). *Berries:* Production is moderate under field conditions.

Tubers

Tuber set typically ranges from 12 to 14. *Shape:* Round and uniform; tubers grown under dryland conditions in North Dakota had a mean length of 6.18 ± 0.9 cm, range 4.2 to 8.5 cm; mean width 5.49 ± 0.7 cm, range 3.5 to 7.3 cm; mean thickness 4.64 ± 0.6 cm, range 3.0 to 6.4 cm (measured from tubers 30.5 to 212.5 g, mean 100.9 ± 37.8 g). *Skin:* Bright white (161B, RHSCC) and smooth textured. *Eyes:* Shallow, number about eight to nine per tuber, and predominately apically distributed. Eyebrows slightly prominent. *Flesh:* White (18D, RHSCC). *Dormancy:* Medium when stored at 3.3 C.

Light Sprouts

Medium red-purple anthocyanin pigmentation at the base; globose shape; closed sprout tip habit; weak red-purple sprout tip pigmentation; strongly hirsute bud and scales; slow development; medium root initial frequency; weak protrusion of lenticels; short lateral shoots.

Morphological characteristics, including leaf, flower, tuber, and light sprouts are presented in Figure 2.

CHARACTERISTICS

Agronomic Performance

Dakota Pearl performed well under both non-irrigated and irrigated conditions in North Dakota, as well as in the North Central Regional Potato Variety Trials (NCRPVT). In non-irrigated trials in North Dakota conducted in 1993-1998, total yields of Dakota Pearl averaged 23.8 t/ha, compared to 31.2, 23.3, 26.0, and 23.2, for cvs NorValley, Norchip, Atlantic, and Snowden, respectively (Table 1). Percentage of U.S. No. 1

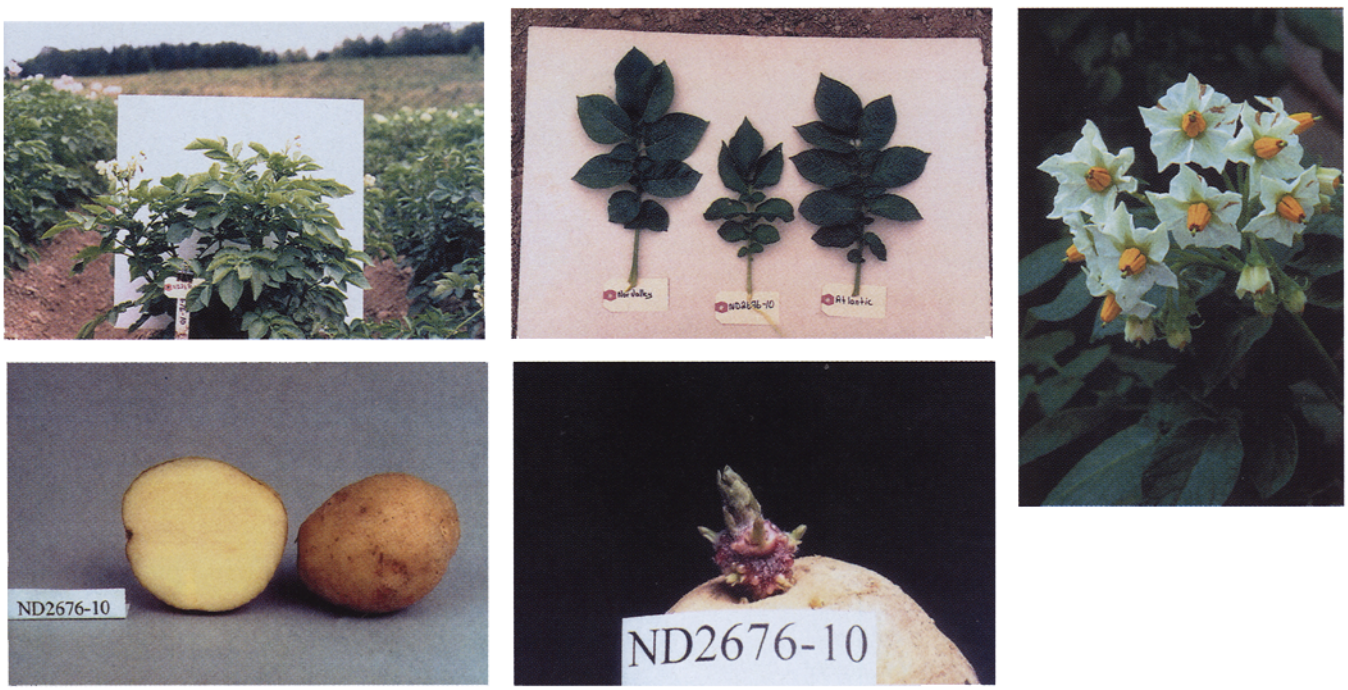

FIGURE 2.
Plant, leaf, flower, tuber and sprout of Dakota Pearl.

tubers was similar for all. Specific gravity for Dakota Pearl was equal to Norchip at 1.090, higher than for NorValley, but slightly lower than for Atlantic and Snowden. Levels were within the acceptable range for chip-processing cultivars. In irrigated trials conducted at six sites in 1994-1998, total yields of Dakota Pearl were comparable to Norchip and NorValley, with a mean of 38.6 t/ha (Table 2); U.S. No. 1 yields were also similar. The specific gravity of Dakota Pearl and the two standard cultivars, both developed by NDSU, were lower than for Atlantic and Snowden.

Results of the North Central Regional Potato Variety Trials showed Dakota Pearl to be widely adapted. The average U.S. No. 1 yield across 23 North American sites during the 3-year evaluation period, 1996-1998, was 35.3 t/ha, compared to 32.6, 35.7, and 36.0, for Norchip, Atlantic, and Snowden, respectively (Table 3). Merit rankings provided by each cooperator placed Dakota Pearl fifth among 19 entries in 1997, and first among 25 entries in 1998. Dakota Pearl was evaluated in the 1994, 1997, and 1998 Snack Food Association Chip Trials (Table 4). Yields were lower than yields of check cultivars Atlantic and Snowden. However, Dakota Pearl was consistently rated among the top three entries for chip color at all trial sites during the three years of evaluation.

Quality Characteristics

A notable processing characteristic of Dakota Pearl is excellent chip quality following 7 months storage at 5.5 C. Results from a 5-year controlled storage evaluation revealed that Dakota Pearl had an average glucose concentration (0.40 mg/g) that was nearly a half to a third lower than those of NorValley (0.71 mg/g) and Atlantic (1.08 mg/g), respectively (Table 5). Dakota Pearl's glucose concentration was similar to ND860-2 (Anonymous 1986), an exceptional breeding selection used as a parent for developing cold-sweetening-resistant selections. Hunter values for chip color were generally commercially acceptable, at >55, following 3 and 5 months storage at 5.5 C with no reconditioning (Table 6).

TABLE 1—*Total and U.S. No.1 tuber yield and tuber specific gravity of Dakota Pearl, NorValley, Norchip, Atlantic, and Snowden potatoes grown in non-irrigated trials at Grand Forks and Park River, ND, and Crookston, MN, in 1993, 1994, 1997, and 1998.*[1]

Cultivar	Year	Tuber Yield		Specific Gravity
		Total	U.S. No. 1[2]	
		t/ha		
Grand Forks	1993			
Dakota Pearl		17.7	16.5	1.091
NorValley		20.5	15.8	1.087
Norchip		20.8	14.5	1.091
Atlantic		-	-	-
Snowden		18.9	15.9	1.099
Park River	1993			
Dakota Pearl		17.2	13.1	1.076
NorValley		34.2	22.5	1.076
Norchip		15.1	8.6	1.078
Atlantic		-	-	-
Snowden		28.2	24.0	1.086
Park River	1994			
Dakota Pearl		24.2	15.0	1.090
NorValley		34.7	20.2	1.093
Norchip		17.9	131	1.092
Atlantic		22.7	14.1	1.099
Snowden		23.7	15.7	1.094
Park River	1997			
Dakota Pearl		25.5	17.0	1.090
NorValley		37.9	31.1	1.081
Norchip		-	-	-
Atlantic		28.9	21.3	1.091
Snowden		23.4	18.9	1.098
Crookston	1998			
Dakota Pearl		34.3	32.0	1.103
NorValley		28.9	25.6	1.088
Norchip		39.5	35.4	1.098
Atlantic		26.5	24.5	1.100
Snowden		21.8	19.5	1.102
Overall Mean				
Dakota Pearl		23.8	18.7	1.090
NorValley		31.2	23.0	1.085
Norchip		23.3	17.9	1.090
Atlantic		26.0	20.0	1.097
Snowden		23.2	18.8	1.096

[1]Trials at Grand Forks were not reported for 1995, 1996, and 1997 due to flooding of plots.
[2]U.S. No. 1 yields reported as 5.08-cm-diameter minimum.

TABLE 2—*Total and U.S. No.1 tuber yield and tuber specific gravity of Dakota Pearl, NorValley, Norchip, Atlantic, and Snowden potatoes grown in irrigated trials at Carrington, Oakes, Dawson, McCanna, and McLeod, ND, and Glyndon, MN, between 1994 and 1999.*

Cultivar	Year	Tuber Yield		Specific Gravity
		Total	U.S. No. 1[1]	
		t/ha		
Carrington, Dawson, and Oakes	1994			
Dakota Pearl		35.6	33.3	1.082
NorValley		38.2	33.9	1.079
Norchip		42.2	37.6	1.078
Atlantic		41.6	39.5	1.093
Snowden		41.5	38.7	1.093
Oakes	1995			
Dakota Pearl		40.8	38.0	1.084
NorValley		52.3	48.6	1.084
Norchip		44.4	37.5	1.085
Atlantic		47.8	44.4	1.092
Snowden		38.3	37.2	1.087
McCanna and Oakes	1996			
Dakota Pearl		39.1	35.7	1.088
NorValley		49.5	44.1	1.085
Norchip		40.2	34.1	1.092
Atlantic		41.2	37.9	1.089
Snowden		38.9	35.8	1.096
McCanna and Oakes	1997			
Dakota Pearl		46.1	41.2	1.081
NorValley		41.0	35.1	1.076
Norchip		49.6	39.2	1.086
Atlantic		49.2	43.4	1.089
Snowden		39.0	35.6	1.093
McCanna and McLeod	1998			
Dakota Pearl		39.4	35.2	1.077
NorValley		40.4	35.3	1.076
Norchip		37.3	31.6	1.079
Atlantic		39.6	34.6	1.087
Snowden		34.2	32.0	1.087
McCanna and Glyndon	1999			
Dakota Pearl		30.6	26.8	1.084
NorValley		25.4	19.7	1.080
Norchip		28.3	22.0	1.082
Atlantic		35.2	31.0	1.094
Snowden		37.3	35.0	1.090
Overall Mean				
Dakota Pearl		38.6	35.0	1.083
NorValley		41.1	36.1	1.082
Norchip		40.3	33.7	1.084
Atlantic		42.4	38.5	1.091
Snowden		38.2	35.7	1.091

[1]U.S. No. 1 yield reported as 5.08-cm-diameter minimum.

Dakota Pearl has consumer appeal as a table-stock cultivar because of its attractive tuber appearance and acceptable sensory evaluation scores following baking, boiling and microwaving (Table 7).

Biochemical and Nutritional Characteristics

Total glycoalkaloid levels are low, averaging 1.5 mg/100 g fresh tuber tissue.

The isozyme profile is distinct and diagnostic, and can be used to identify the cultivar when compared to similar cultivars. Isoelectric focusing electrophoresis (IEF) was performed on potato tuber protein extracts using the method and gels developed by Perkin-Elmer Life Sciences, Norton Ohio. Separate tests were conducted from tuber proteins and the enzyme esterase for samples of cvs Dakota Pearl, NorValley, Brodick, and Norchip.

IEF analysis of tuber proteins stained with a general protein stain (brilliant blue R-250) revealed unique protein banding patterns or fingerprints for these cultivars. The diagnostic area of the gel was found in the 40- to 71-mm range as measured from the edge of the anode wick towards the cathode wick (gel not shown). Dakota Pearl had prominent bands at 42, 58, 60, 61.5, 64, 66, 68, and 71 mm. The band at 42 mm was unique to Dakota Pearl. NorValley has major bands at 58, 61.5, 63, 66, and 68 mm. Three bands in the diagnostic area were prominent for Brodick at 60, 63, and 68 mm. Analysis of Norchip revealed prominent bands at 58, 61.5, 64, 66, 68, and 71 mm.

IEF analysis of the enzyme esterase also revealed unique banding patterns for these four cultivars (gel not shown).

Disease Response, Bruising, and Physiological Disorders

During evaluation, Dakota Pearl exhibited no notable disease or pest resistance, nor exceptional susceptibility. Hollow heart was noted in irrigated trials in North Dakota in 1998. Susceptibility to heat necrosis was reported in trials conducted in North Carolina in 1998. Internal necrosis has occasionally

been noted in grower fields. Symptom expression of bacterial ring rot is typical for both vine and tubers, with foliar expression, including leaf necrosis, leaf rolling, and interveinal chlorosis, observed 80 to 90 days after planting in the Red River Valley. However, wilting associated with bacterial ring rot infection was not observed.

UTILIZATION

Dakota Pearl was developed for and is suited to the manufacture of potato chips. It may be marketed directly from the field as an early or full-season crop, or following storage. Dakota Pearl may double as a tablestock cultivar due to attractive tuber appearance and acceptable baked, boiled, and microwaved products (Table 7).

MANAGEMENT

Certified seed should be planted to maximize performance of Dakota Pearl. Dakota Pearl has medium dormancy. Sprout inhibitors should be applied about 2 months after harvest to minimize sprouting. If sugar levels accumulate above desirable levels, Dakota Pearl may be effectively reconditioned by raising the storage temperature to approximately 18.3 C for 2 to 4 wk.

Dakota Pearl was moderately susceptible to the herbicide metribuzin when screened using the technique developed by Love et al. (1993). In 2003 foliar damage was 30% 21 days after the post-emergent treatment. Yield loss was calculated at 6% (Thompson et al. 2004).

AVAILABILITY

Plant Variety Protection was sought on behalf of the NDSU Research Foundation for Dakota Pearl. Protection for certificate 200000232 is pending. Tissue-culture-based limited-generation seed, including micropropagated plantlets and minitubers, is available from the North Dakota State Seed Department and others. Certified seed of Dakota Pearl is available from producers in North Dakota and Minnesota, in addition to other states and Canadian provinces. Small amounts for research purposes can be obtained by contacting the corresponding author.

TABLE 3—*Total and U.S. No.1 tuber yield and tuber specific gravity of Dakota Pearl, NorValley, Norchip, Atlantic, and Snowden potatoes grown in North Central Regional Potato Variety Trials in 1996 to 1998.*[1]

Cultivar	Year	Tuber Yield Total	Tuber Yield U.S. No. 1[2]	Specific Gravity	Rank[3]
		t/ha			
Dakota Pearl	1996	32.3	27.8	1.080	4
Norchip		31.7	26.2	1.078	5
Atlantic		38.6	35.5	1.088	4
Snowden		34.9	31.6	1.083	1
Dakota Pearl	1997	33.0	28.1	1.074	5
Norchip		32.7	26.2	1.075	0
Atlantic		32.5	29.0	1.082	3
Snowden		35.3	31.4	1.080	4
Dakota Pearl	1998	40.5	34.0	1.080	16
Norchip		33.4	30.4	1.081	0
Atlantic		36.2	31.2	1.091	11
Snowden		37.9	33.6	1.089	3
Overall					
Dakota Pearl		35.3	30.0	1.078	8
Norchip		32.6	27.6	1.078	2
Atlantic		35.7	31.9	1.087	6
Snowden		36.0	32.2	1.084	3

[1]North Central Regional Potato Variety Trial was grown at eight locations in 1996 and 1997; reported means do not include data from Louisiana or North Dakota in 1996 due to very dry followed by very wet conditions and flooding, respectively. In 1997, reported means do not include data from Iowa, Louisiana or North Dakota due to flooding, except for specific gravity that includes all except for Louisiana. Eight states and two Canadian provinces participated in the NCRPVT in 1998; means presented do not include Alberta and Nebraska due to Sencor damage and psyllid damage, respectively.

[2]U.S. No. 1 yields reported as 5.08-cm-diameter minimum.

[3]Rank determined by merit rating values of 1 to 5, with point values corresponding to 5 to 1. Value reported equals total points earned; the higher the value the greater the merit.

TABLE 4—*Total and U.S. No.1 tuber yield and tuber specific gravity of Dakota Pearl, NorValley, Norchip, Atlantic, and Snowden potatoes grown in the Snack Food Association Trials in 1994, 1997, and 1998.*[1]

Cultivar	Tuber Yield Year	Total	U.S. No. 1[2]	Specific Gravity	Rank[3]
		t/ha			
Dakota Pearl	1994	38.3	34.5	1.080	64
NorValley		39.6	34.6	1.078	60
Norchip		37.1	32.6	1.081	59
Atlantic		37.2	34.5	1.092	58
Snowden		-	-	-	-
Dakota Pearl	1997	28.4	22.1	1.079	61
NorValley		-	-	-	-
Norchip		-	-	-	-
Atlantic		34.8	31.0	1.089	58
Snowden		37.7	32.1	1.087	57
Dakota Pearl	1998	33.9	36.2	1.075	64
NorValley		-	-	-	-
Norchip		-	-	-	-
Atlantic		38.4	33.4	1.086	59
Snowden		36.7	30.2	1.083	63
Overall Mean					
Dakota Pearl		33.5	27.6	1.078	63
NorValley		39.6	34.6	1.078	60
Norchip		37.1	32.6	1.081	59
Atlantic		36.8	33.0	1.089	58
Snowden		37.2	32.3	1.085	60

[1]1994 and 1998 locations include California, Florida, Maine, Pennsylvania, Michigan, Red River Valley, and Washington. 1997 locations include California, Florida, Maine, Michigan, and the Red River Valley.
[2]U.S. No. 1 yields reported as 5.08-cm-diameter minimum.
[3]Agtron values = spectral reflectance; values of 55 or higher denote acceptably colored potato chips. Values provided are a mean of values reported from the different localities primarily following harvest.

TABLE 5—*Relative glucose concentrations following 7 months storage at 5.5 C (1998-2003).*

Clone	Glucose[1] mg/g FW
Dakota Pearl	0.40
ND860-2	0.38
Snowden	0.67
NorValley	0.71
Atlantic	1.08
Norchip	2.16

[1]Readings represent a five year average. Each year's value was obtained from a composite sample taken from eight tubers.

TABLE 6—*Average chip color (reported as Agtron values) of Dakota Pearl, ND860-2, NorValley, Norchip, Atlantic, and Snowden, from 3.3 and 5.5 C at 3 and 5 months storage, respectively.*[1]

	Chip Color[2] 3.3 C 5 months			5.5 C 3 months			5.5 C 5 months		
Clone	1998	1999	2000	1998	1999	2000	1998	1999	2000
Dakota Pearl	50	43	50	60	59	62	56	55	54
ND860-2	54	45	51	65	58	61	55	56	54
NorValley	40	38	46	56	55	60	56	57	51
Norchip	38	35	36	45	40	61	41	36	46
Atlantic[3]	-3	-	39	47	-	56	-	-	49
Snowden	46	38	48	52	51	53	55	52	56

[1]Data represents an average from six potato tubers.
[2]Agtron values = spectral reflectance; values of 55 or higher denote acceptably colored potato chips.
[3]Dash indicates data not available.

TABLE 7—*Sensory evaluation of Dakota Pearl, NorValley, Norchip, Atlantic, and Snowden from 1992 to 1998.*[1]

		Boiling				Baking			Microwaving			
Cultivar	Sloughing	Color	Color 4 hrs	Summation Mealiness	Flavor	Color	Mealiness	Flavor	Color	Mealiness	Flavor	of Values
Non-irrigated												
Dakota Pearl	5.6	7.9	6.8	6.5	6.4	8.0	6.6	6.7	7.4	6.3	6.7	76.2
NorValley	7.4	7.2	6.2	6.1	6.2	8.2	6.9	6.6	7.7	6.8	6.5	75.8
Norchip	7.5	8.0	7.3	5.7	6.6	8.1	6.7	6.8	7.8	6.3	6.6	77.4
Atlantic	4.8	7.3	7.1	7.3	6.4	8.3	7.4	6.5	7.4	7.4	6.6	74.9
Snowden	5.5	7.1	6.4	6.7	5.4	7.7	7.1	5.7	7.1	6.9	5.8	71.1
Irrigated												
Dakota Pearl	5.3	7.9	6.5	5.5	5.5	8.0	5.8	5.6	7.7	5.1	5.8	68.7
NorValley	7.2	8.6	5.9	4.6	5.9	8.4	6.0	5.7	7.8	5.3	5.9	71.3
Norchip	7.3	8.6	6.8	5.0	5.8	8.1	5.7	5.9	8.1	5.4	6.2	72.9
Atlantic	5.7	8.5	7.2	6.6	6.2	7.8	6.6	6.3	7.9	6.6	5.9	75.8
Snowden	4.1	8.3	7.7	7.0	5.8	8.3	6.9	5.4	7.1	6.2	6.0	72.9

[1]Two replicates per trial of each entry were evaluated by a three- to five-member panel in a blind taste test. Characteristics are rated on a 1-9 scale, poor to excellent. Higher values are desirable for the traits evaluated. Non-irrigated site means include 1992 to 1998. Irrigated site means include 1996 to 1998.

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